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To bid or not to bid: An empirical study of the supply determinants of crowd-shipping

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ABSTRACT

This study makes three contributions to the literature of crowd-shipping. First, we represent a national data set incorporating 16,850 crowd-shipping requests across the United States for the 2-year period of January 2015 through December 2016. Second, we develop a two-part model of supply defined by both the probability of receiving a bid from a crowd-courier, and the bid count. Model results along with elasticity measurements summarize the effects of variation in shipping request and package, built environment, and socioeconomic characteristics. Third, we report the sensitivity of elasticities over different segmentations to understand whether and to what extent the supply responsiveness varies across segments. Our results show that (1) supply is unevenly distributed across the U.S. at the block group level, (2) this geographical disparity is a function of not only the shipping request and service characteristics, but also the socioeconomic and built-environment attributes, (3) the supply has denser pockets in areas with a higher percentage of African-American population, high wage workers, and families with two or more vehicles, (4) the supply peters off in areas with higher population and employment densities, while, it is accumulated in geographical areas with higher destination accessibility and regional employment diversity, and (5) the out-of-state and the business-to-customer shipments present the highest elasticity in receiving a bid, while posted requests with a delivery deadline is the most inelastic segment. Transportation planners and crowd-shipping companies can use these results to implement improved supply creation, geographically targeted growth, and price discrimination strategies.

1. Introduction

Facilitated by the ubiquity of communication and computing technologies, the rapid development of crowdsourcing has enabled businesses to offer on-demand delivery of goods to consumers through crowds (Kafle et al., 2017). By using crowd-sourcing for logistics services, businesses have the potential to optimize service production and delivery by targeting and leveraging unused resources. Crowd-shipping (CS), by definition, connects service requesters with other citizens who are traveling, or accept to travel, from point A to point B to deliver a shipment (Cohen and Muñoz, 2016). In this arrangement, CS businesses play an intermediary role in connecting the service requester and the professional or occasional couriers, managing matching, payments and service guarantees.

With the introduction of crowdsourcing in the shipping market, a number of online platforms have emerged using distinct business models. The CS business models are comprised of business-to-business, business-to-customer, and peer-to-peer markets at different geographical scales (Rai et al. 2017, Rougès and Montreuil, 2014). However, the main operations are similar across business

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models. The crowd-shipping platform functions in three steps. First, a shipment order is posted on the website or application of the crowd-shipping company. The service requester delineates the size of the package, the pick-up and drop-off locations, and any delivery time requirements in this step. Second, CS platforms use distinct approaches for matching the service requester and the courier, ranging from centralized: (1) the platform matches the sender and courier centrally using algorithms that optimize the delivery probability; to decentralized (2) where the sender selects directly from a list of available/willing couriers who bid on the request. Third, if the request receives any bids, the client selects one of the couriers and pick-up/delivery arrangements are made. The CS market emerged to alleviate inefficiencies in the last mile delivery (Marcucci et al., 2015; Nourinejad et al., 2014; Arvidsson, 2013), and to respond to the rapid changes in consumer and shopping behavior. The long-term success of this new model, however, is inextricably intertwined with the crowd itself, and whether and to what extent platforms are able to attract a sufficiently large number of participants. This is a critical matter in the start-up phase of CS services, as failing to provide adequate supply for the posted requests discourages customers from using the service (Rougès and Montreuil, 2014). Any negative experiences can have a ripple effect by dissuading other potential customers to try the service, which consequently diminishes the demand of the CS services and could dismantle the market. Despite the importance, little is known about the influential factors on the supply side of CS services.

The current study therefore makes three contributions to the nascent but growing CS literature. *First*, many of the previous studies have been limited to solving the routing and matching problems along with describing the CS operation and its pros and cons. The bulk of this work is carried out for theoretical instances or using opportunistic or aggregated data from other contexts (e.g. taxi-trajectories). The knowledge about the performance of actual CS systems and factors associated with the supply of the system is still rudimentary. This deficiency stems from the lack of availability of comprehensive real operational data. We overcome this challenge by using a national data set incorporating 16,850 CS requests across the United States for the period of January 2015 through December 2016. *Second*, we test a two-part model that represents two essential measures of the supply of CS couriers, namely the probability of receiving a bid and the number of bids. Model results and elasticity measurements summarize the effects of variation in (a) shipping request and package features, (b) built environment, and (c) socioeconomic characteristics. *Third*, we expand this comparison by measuring the sensitivity of elasticities over different segments to understand how the supply responsiveness varies. In particular, we aim to respond to the following research questions:

1. Which shipping request attributes, such as the size of packages, delivery distance, delivery cost, delivery deadline, and time of posting a request, are correlated with the supply of CS?
2. Which built environment and socioeconomic attributes are correlated with the supply of CS?
3. Is the supply side of CS altered by characteristics of both pick-up and drop-off locations? If so, which one is most influential?
4. What is the degree of sensitivity in response to characteristics informing the supply of CS over different segments?

Answering these questions will shed light on the supply side of the system and will form the basis for implementing effective policies to augment the supply where it is needed and leverage the driver supply more efficiently across the system.

The remainder of the paper is organized as follows. First, we review the related CS literature systematically. Second, we discuss the data used in this study and provide a descriptive analysis of the data. Third, we represent the two-step model of supply along with the results of the model. In the penultimate section, we provide an in-depth qualitative and quantitative analysis of the supply side of CS services. We conclude the paper by summarizing the main findings of the study and broaching a number of practical implementations.

2. Literature review

Before narrowing the focus of this research, we intend to review the burgeoning literature of CS systematically, as a transparent, rigorous, and explicit methodology review (Booth et al., 2016). This systematic search is limited to English language articles. We employ the following four search steps for our literature review:

(1) We searched existing articles in Google Scholar and Scopus academic search engines using all-inclusive keywords. Initially, we began with the keyword “Crowd-shipping” to extract the relevant articles. The primary screening of results, however, reveals that not only are the terms “Crowd” and “Crowd-sourced” used interchangeably, but also “Delivery” and “Logistic” terms are frequently used as a substitute of “shipping.” We hence broaden our keywords search by using different combinations of terms to embody a wide spectrum of studies. The final keywords consist of “Crowd Delivery,” “Crowd Logistics,” “Crowd-shipping,” “Crowd-sourced Delivery,” “Crowd-sourced Logistic,” and “Crowd-sourced Shipping.” This resulted in 164 articles. We removed the duplicated results, which left 139 articles.

(2) The authors scanned all 139 articles to identify the potentially relevant articles. The articles were then partitioned into three distinct categories based upon the relevancy:
   - Keywords Appeared: This category includes studies where one of the searched keywords appears in the references or the body of the article, while there is no discussion around the topic.
   - Discussion Appeared: A significant number of extracted articles discuss the state-of-the art of CS systems in a broader and occasionally unrelated context. These articles, which are not necessarily scholarly research papers, focus on defining the system, discussing the pros and cons of the system as an example of crowdsourcing, or proposing CS as a research extension for further research.
   - Analysis Appeared: This category of articles focuses on analyzing CS explicitly. These studies look at the CS either as a door-to-